A NOTE ON KING'S ARTICLE ON "THE CORRELATION OF HISTORICAL ECONOMIC VARIABLES AND THE MISUSE OF COEFFICIENTS IN THIS CONNECTION."

Errors in the conception of correlation and the use of the correlation coefficient are so common a vice of pseudo-scientific research that any attempt to correct their influence would be a bootless task. Mistakes of this sort mark the beginnings of any newer branch of scientific knowledge and may be looked upon as natural growing pains. Were Dr. King's article in the December number of the QUARTERLY PUBLICATIONS the first fruit of an immature worker in an uncultivated field, it might be allowed to pass without comment. But Dr. King's standing among American statisticians and the appearance of his article in the publications of the American Statistical Association place the matter in a different light, and justify an explicit challenge to the contentions he sets forth.

The gist of Dr. King's argument runs as follows: (1) the correlation coefficient is being employed to demonstrate utterly fallacious conclusions, especially in the analysis of historical data; (2) such errors rest in part upon neglect of the fact that correlation always indicates causation; (3) in part the errors are due to failure to separate adequately the forces contributing to the given events; (4) if causal forces are thoroughly isolated, correlation in every case will be perfect; (5) for demonstrating whether correlation does or does not exist, "no coefficient equals the graphic method"; (6) in the study of historical economic variables, the correlation coefficient serves but one purpose—namely, to measure the lag, if there be any.

One need not question Dr. King's contention that the correlation coefficient has been too often employed to support conclusions which have been "utterly fallacious and entirely contrary to the facts." Few statistical devices are "foolproof," and the more delicate the device the more liable it is to misuse by the inexpert. Dr. King's indictment, however, might well have been made more specific. Blundering by the novice is one thing; error by the scientist is another. One can not but feel that much of Dr. King's bill of complaint is irrelevant to the work of statisticians of measurable professional standing. If this be the case, the fact might well have been made clear.

But it is in his analysis of correlation and the correlation coefficient that Dr. King is most unfortunate. His discussion of the nature of correlation is so extreme and inflexible as to be wholly misleading. To Dr. King, correlation invariably connotes established causal relationship. Since "every cause must produce its effect exactly and invariably," it follows that "there can be no such thing as imperfect or partial correlation." "Every correlation to exist must be perfect." Correlation coefficients less than unity indicate that cause and effect have not been completely isolated; they evidence the confusion or deficiency of our measurements, not any imperfection of the correlation itself.

If correlation were being defined *de novo*, it is possible that this view might prevail. But the term "correlation" has an established meaning.

Correlation is not identical with causation, though closely connected with it. Correlation connotes a tendency toward persistent association. In other words correlation is "a tendency toward concomitant variation." As Bowley states it (Elements of Statistics, p. 316): "When two quantities are so related that the fluctuations in one are in sympathy with the fluctuations of the other, so that an increase or decrease of one is found in connection with an increase or decrease (or inversely) of the other, and the greater the magnitude of the change in the one, the greater the magnitude of the change in the other, the quantities are said to be correlated." By established usage and authority, correlation is nothing more than "one-to-one" correspondence in paired items of selected variables.

If this is the nature of correlation, what is its relation to causation? The case of perfect correlation may be first considered. Perfect correlation is a theoretical or conceptual limit to the more or less imperfect correlations of the world of experience.* Actual correlations, nevertheless, sometimes approach perfect correlation so closely as to share its nature. Such approximately-perfect correlations afford indisputable evidence of (1) joint characteristics of single entities (*e. g.*, the height and weight of adult males), or (2) that consistent routine of events which we designate causal connection. Complete correlation in the first of these cases informs us that we may expect to find invariably associated with a given characteristic of an object a stated measure of a second characteristic. Complete correlation in the second case informs us that we may expect to find a given event—designated cause—invariably followed by a second—designated effect.†

If correlation were always perfect, the problem would be relatively simple. Unfortunately for Dr. King's exposition, data drawn from experience—even artificially controlled experience—never exhibit perfect correlation. The essential task of correlation studies lies in the interpretation of concrete evidence, not in the understanding of conceptual limits. In general the question raised by actual data is a question of probability: Do the data show a degree of correspondence greater than was to have been expected from chance? If not, there is no evidence of a tendency toward persistent association, and hence no evidence of correlation. If the degree of correspondence, however, exceeds that which was to have been expected from chance, correlation may be postulated with a confidence varying directly as the excess.

It is clear enough that, when cause and effect are absolutely segregated, correlation becomes complete and obvious. Such complete—or virtually complete—segregation of forces is the ideal of causal analysis. Dr. King cites three reasons for the failure of economic analysis to attain this ideal: (1) failure to comprehend the factors involved; (2) lack of information essential to the separation of the forces; (3) ignorance of proper statistical methods. Unfortunately he neglects the reason which is most funda-

* An analogous statement may be made, of course, of perfect independence.

† Conceivably the joint characteristics of the first case may be thought of as coupled effects of a common cause; thus bringing the case within the class of causal connections. But ordinarily nothing is to be gained by this view of the matter. Whether or not the two cases at bottom are alike causal, their separation in practice is helpful.

mental: the practical impossibility of isolating economic forces completely. Dr. King, in suggesting the complete segregation of forces in economic analysis, is not merely giving a counsel of perfection; he is proposing what is manifestly impossible. The events of economic life are the product of an intricate, complex, maelstrom of forces. Economic science is replete with examples of the misfortunes attending attempts to abstract influences from this social complex: what the analysis gains in simplicity, it loses in reality and applicability. Segregation of forces in economic analysis must be effected with the utmost care, and can never be more than partial.

Dr. King makes much of a parallel between the methods of economic and physical science. Unquestionably economic research might profit greatly from wider and more intimate acquaintance with the methods of the more exact sciences. But a warning should be given against the tendency of making research in social science an exact and mechanical process. It is unsafe to conduct economic studies with mathematical automatons. In the first place, in most cases the original measurements are not sufficiently accurate to justify refined methods of analysis. And secondly, the analysis itself is a succession of acts of selection and interpretation calling for the highest order of intelligence. If left to itself, statistical method soon runs amuck. If it is to be successful, there must be wise and steadying guidance. Nothing is more mistaken than the widely-held notion that statistical method, because of the precision of its mathematical processes, yields perfectly dependable results. It is to be hoped that statistical method will make the hypotheses of economic science somewhat more trustworthy; for with the aid of this method *presumptions* of causal connection may surely be more firmly established. But it is one of the unavoidable limitations of economic science that its laws must remain openly in the presumptive form. Fortunately the laws may be made to serve none the less as satisfactory working hypotheses for private and public policy.

Nothing that has been said should be construed as in opposition to as thorough a separation of forces as is practicable in economic analysis. In the study of time series, secular trend, cyclical movements, and seasonal fluctuations should be carefully distinguished. Data should be selected with a view to their "greatest possible homogeneity." Studies of correlation should be supplemented with studies of "partial correlation." Unfortunately these latter practices, involving as they do a restriction of the "universe of discourse," sacrifice wealth of material to uniformity of data, and by basing conclusions necessarily upon a smaller body of evidence increase the probable error of the result. When all is said and done, a large margin of uncertainty thus is bound to persist in economic science. Much more is to be gained by acknowledging this fully than by underrating its significance.

Dr. King's argument leads him to discount the use of the correlation coefficient. If all correlations were perfect, he could well afford to do so; perfect correlation, if actually encountered, would be simple enough to deal with. It is just because correlation is never perfect that the coefficient is invaluable. As has been stated, the significance of a given association of

paired variables depends entirely upon the extent to which the association exceeds that to be expected from chance. The correlation coefficient enables an exact measurement of this all-important relationship. For this purpose curves are worthless. Curves may yield valuable suggestions for further study; they may prove effective graphic representations of correlation. In general they are a treacherous instrument for *proving* correlation. For this purpose nothing equals the correlation coefficient.

In the analysis of time variables, Dr. King would limit the use of the coefficient to the measurement of lag. Nothing could be more ill-advised. It is true that the correlation coefficient in its original form was not adapted to the study of fluctuations in time. But the "method of differences" corrects this deficiency and restores the coefficient to its position as the most serviceable measure of correlation, for historical as for other variables.

It is difficult to say to what extent the defects of Dr. King's article arise from mere excess of statement in giving a warning, the need of which all might concede. Dr. King's contributions to the literature of statistics are a sufficient guarantee that we need fear no abuse of statistical method at his hands. Unfortunately his December article gives no equal assurance for others. Upon the contrary there is reason to believe that it will add materially to that confusion regarding the nature of correlation and the correlation coefficient which it has been Dr. King's intention to correct.

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